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### Amendments to the Claims

Please amend claims 1-3,5-8, 11-13, 20, 21, 27, 30, 31, 37-39, 41, 43, 45-47, 54, 56-59, 63-65, 68-71, 74-78, 80-82, 88, and 89; cancel claims 9, 10, 15, 24-26, 32-36, 42, 44, 79, and 94-96; and add new claims 97-112 as set out below.

1. (Currently Amended) A method for depositing a ruthenium thin film onto a substrate, said method comprising:

(a) depositing a nucleation layer comprising ruthenium metal onto the substrate by chemical vapor deposition, wherein the nucleation layer is deposited using a nucleation layer first ruthenium precursor/co-reactant gas mixture having greater than about 30 mole percent of the co-reactant gas, under nucleation layer CVD conditions including a temperature of from about 250°C to about 340°C and a ruthenium precursor gas flow rate that is sufficient to maintain a surface reaction rate-limited deposition; and

(b) depositing an upper layer comprising ruthenium metal onto the nucleation layer by chemical vapor deposition, wherein the upper layer is deposited using a second ruthenium precursor/co-reactant gas ~~an upper layer~~ mixture having less than 50 mole percent of the co-reactant gas under upper layer CVD conditions, including a ruthenium precursor gas flow rate that is less than that needed to maintain a surface reaction rate-limited deposition.

2. (Currently Amended) The method of claim 1, wherein the upper layer CVD conditions are more reducing than the nucleation layer CVD conditions ~~comprises ruthenium oxide~~.

3. (Currently Amended) The method of claim 1, wherein the ruthenium precursor gas flow rate for the nucleation layer is in a range of from about 2 µmol/min to about 100 µmol/min ~~nucleation layer CVD conditions comprise temperature in a range of about 250°C and about 340°C~~.

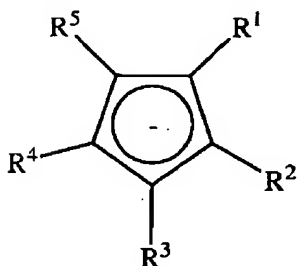
4. (Original) The method of claim 1, wherein the nucleation layer CVD conditions comprise pressure in a range of about 0.1 Torr and about 8 Torr.

5. (Currently Amended) The method of claim [[4]] 1, wherein the nucleation layer CVD conditions comprise pressure in a range of about 0.4 Torr to about 1.6 Torr.

6. (Currently Amended) The method of claim 1, wherein ~~the nucleation layer mixture~~ at least one of the first and second ruthenium precursor/co-reactant gas mixtures further comprises a first ruthenium precursor, a first co-reactant gas, and optionally a first an inert gas.

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7. (Currently Amended) The method of claim [[6]] 1, wherein the first and second ruthenium precursors are the same precursor ~~comprises a solid~~.
8. (Currently Amended) The method of claim [[6]] 1, wherein the first and second ruthenium precursors are different ~~precursor~~ ~~comprises a liquid~~.
9. (Cancelled).
10. (Cancelled)
11. (Currently Amended) The method of claim [[6]] 1, wherein ~~the nucleation layer mixture~~ ~~comprises the first co-reactant gas at a concentration of from~~ about 80 mole% to about 95 mole% of the first ruthenium precursor/co-reactant gas mixture is a co-reactant gas, based on the total number of moles of the nucleation layer mixture.
12. (Currently Amended) The method of claim [[6]] 11, wherein the first co-reactant gas comprises oxygen.
13. (Currently Amended) The method of claim [[6]] 1, wherein the first and the second ruthenium ~~precursor~~ ~~comprises a ruthenium compound~~ precursors are independently selected from the group consisting of ruthenocenes, ruthenium  $\beta$ -diketonates, fluorinated ruthenium  $\beta$ -diketonates, ruthenium carbonyls, ruthenium oxides and ruthenium halides.
14. (Original) The method according to claim 13, wherein the ruthenocenes have the formula  $(Cp')Ru(Cp'')$ , where  $Cp'$  and  $Cp''$  can be same or different and have the general formula:



where  $R^1 - R^5$  are independently selected from the group consisting of H, F, and straight-chained or branched  $C_1 - C_5$  alkyl groups.

15. (Cancelled)
16. (Original) The method of claim 13, wherein the ruthenocene comprises  $Ru(EtCp)_2$  or  $Ru(Cp)_2$ .



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27. (Currently Amended) The method of claim 1, wherein the upper layer consists essentially of ruthenium metal.
28. (Original) The method of claim 1, wherein the upper layer CVD conditions comprise temperature in a range of about 280°C and about 400°C.
29. (Original) The method of claim 1, wherein the upper layer CVD conditions comprise pressure in a range of about 0.1 Torr and about 2 Torr.
30. (Currently Amended) The method of claim ~~[[29]]~~ 1, wherein the upper layer CVD conditions comprise pressure in a range of about ~~[[0.4]]~~ 0.2 Torr to about 1.0 Torr.
31. (Currently Amended) The method of claim 1, wherein both the first and the second ruthenium precursor/co-reactant gas mixtures further comprise an the upper layer mixture comprises a second ruthenium precursor, a second co-reactant gas, and optionally a second inert gas.
- 32-36. (Cancelled)
37. (Currently Amended) The method of claim ~~[[31]]~~ 1, wherein ~~the upper layer mixture comprises the second co-reactant gas at a concentration of from about 1 mole% by weight to about 10 mole% of the second ruthenium precursor/co-reactant gas mixture is the co-reactant gas, based on the total number of moles of the upper layer mixture.~~
38. (Currently Amended) The method according to claim ~~[[31]]~~ 37, wherein the second co-reactant gas comprises oxygen.
39. (Currently Amended) The method according to claim ~~[[31]]~~ 37, wherein the second co-reactant gas comprises an oxygen:hydrogen gas mixture.
40. (Original) The method of claim 39, wherein the oxygen:hydrogen gas mixture has a mole ratio in a range of about 1:1 to about 1:3.
41. (Currently Amended) The method of claim ~~[[31]]~~ 13, wherein the first and the second ruthenium precursors are the same precursor comprises a ruthenium compound selected from the group consisting of ruthenocenes, ruthenium  $\beta$ -diketonates, fluorinated ruthenium  $\beta$ -diketonates, ruthenium carbonyls, ruthenium oxides and ruthenium halides.
42. (Cancelled)
43. (Currently Amended) The method according to claim ~~[[41]]~~ 13, wherein the first and the second ruthenium precursors are different ruthenocene comprises Ru(EtCp)<sub>2</sub> or Ru(Cp)<sub>2</sub>.

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44. (Cancelled)

45. (Currently Amended) The method of claim [[41]] 43, wherein the first ruthenium precursor is selected from the group consisting of ruthenium  $\beta$ -diketonates, fluorinated ruthenium  $\beta$ -diketonates, ruthenium carbonyls, and ruthenium oxides and second ruthenium precursor is selected from the group consisting of ruthenocenes, ruthenium  $\beta$ -diketonates, fluorinated ruthenium  $\beta$ -diketonates, ruthenium carbonyls, ruthenium oxides and ruthenium halides ~~ruthenium  $\beta$ -diketonate comprises a compound selected from the group consisting of: tris(2,4-pentanedionate) ruthenium ( $\text{Ru}(\text{acac})_3$ ); tris(1,1,1-trifluoro-2,4-pentanedionate) ruthenium ( $\text{Ru}(\text{tfac})_3$ ); tris(2,2,6,6-tetramethyl-3,5-heptanedionate) ruthenium ( $\text{Ru}(\text{thd})_3$ ); tris(1,1,1,5,5,5-hexafluoro-2,4-pentanedionate) ruthenium ( $\text{Ru}(\text{hfac})_3$ ); tris(2,2,7-tetramethyl-3,5-octanedionate) ruthenium ( $\text{Ru}(\text{tod})_3$ ); tris(6,6,7,7,8,8,8-heptafluoro-2,2-dimethyl-3,5-octanedionate) ruthenium ( $\text{Ru}(\text{fod})_3$ ); and tris(2,4-octanedionate) ruthenium ( $\text{Ru}(\text{od})_3$ ).~~

46. (Currently Amended) The method of claim [[41]] 43, wherein the first ruthenium precursor is a ruthenium  $\beta$ -diketonate and the second ruthenium precursor is a ruthenocene ~~comprises  $\text{Ru}(\text{thd})_3$  or  $\text{Ru}(\text{hfac})_3$ .~~

47. (Currently Amended) The method of claim [[31]] 1, wherein the rate of introduction of the second ruthenium precursor is in a range of about 5  $\mu\text{mol}/\text{min}$  to about 20  $\mu\text{mol}/\text{min}$ .

48. (Original) The method of claim 1, wherein the resistivity of the ruthenium thin film is in a range of about 8  $\mu\Omega\text{-cm}$  to about 25  $\mu\Omega\text{-cm}$ , and has a thickness in a range of from about 10.0 nm to about 35.0 nm thick.

49. (Original) The method of claim 1, wherein the resistivity of the ruthenium thin film is in a range of about 12  $\mu\Omega\text{-cm}$  to about 25  $\mu\Omega\text{-cm}$ , and has a thickness in a range of from about 5.0 nm to about 15.0 nm thick.

50. (Original) The method of claim 1, wherein the resistivity of the ruthenium thin film is in a range of about 20  $\mu\Omega\text{-cm}$  to about 125  $\mu\Omega\text{-cm}$ , and has a thickness in a range of from about 2.0 nm to about 5.0 nm thick.

51. (Original) The method of claim 1, wherein the resistivity of the ruthenium thin film is in a range of about 10  $\mu\Omega\text{-cm}$  to about 100  $\mu\Omega\text{-cm}$ .

52. (Original) The method of claim 1, wherein the thickness of the ruthenium thin film is in a range of about 25 Å to about 350 Å.

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53. (Original) The method of claim 1, wherein the rate of deposition of the upper layer is in a range of about 5 Å/min to about 1 Å/min.
54. (Currently Amended) The method of claim ~~[[32]]~~ 1, wherein the source of either or both ruthenium precursors in the respective gas mixture is a solid and is delivered ~~delivery of the upper layer mixture to the chemical vapor deposition chamber~~ ~~[[is]]~~ by a solid delivery approach.
55. (Original) The method of claim 54, further comprising the separate addition of a solvent to the solid delivery approach.
56. (Currently Amended) The method of claim ~~[[33]]~~ 1, wherein the source of either or both ruthenium precursors in the respective gas mixture is a liquid or a solution and is delivered ~~delivery of the upper layer mixture to the chemical vapor deposition chamber~~ ~~is by~~ a liquid delivery approach.
57. (Currently Amended) The method of claim 1, further comprising the step of annealing the nucleation layer prior to deposition of the upper layer.
58. (Currently Amended) The method of claim 1, wherein from about 80 mole% to about 90 mole% of the first ruthenium precursor/co-reactant gas mixture is oxygen ~~further comprising annealing the ruthenium thin film following deposition of the upper layer on the nucleation layer.~~
59. (Currently Amended) The method of claim ~~[[31]]~~ 1, wherein from about 80 mole % to about 95 mole % of the first ruthenium precursor/co-reactant gas mixture is oxygen and from about 1 mole % to about 20 mole % of the second ruthenium precursor/co-reactant gas mixture is oxygen ~~precursor is different than the first ruthenium precursor.~~
60. (Original) The method of claim 1, wherein the ruthenium thin film has an impurity content of less than about 2 atomic%.
61. (Original) The method of claim 1, wherein the substrate comprises a metallic portion and a dielectric portion.
62. (Original) The method of claim 61, wherein the nucleation layer on the metallic and dielectric portions of the substrate is a peel-resistant layer film.
63. (Currently Amended) The method of claim 59 wherein the second co-reactant gas is a mixture of oxygen and hydrogen ~~1, wherein the rate of deposition of the upper layer is less than a rate of surface reaction rate limited deposition to deposit a ruthenium thin film having an impurity content of less than about 2 atomic%.~~

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64. (Currently Amended) The method of claim 1, wherein each co-reactant gas is individually selected from the group consisting of oxygen, hydrogen, steam, nitrous oxide, ozone, carbon monoxide, carbon dioxide, and mixtures of oxygen and hydrogen ~~the ruthenium thin film comprises the nucleation layer and the upper layer.~~

65. (Currently Amended) A method for depositing a ruthenium thin film onto a substrate, said method comprising:

(a) depositing a nucleation layer comprising ruthenium onto the substrate by chemical vapor deposition, wherein the nucleation layer is deposited from a nucleation layer ruthenium precursor/co-reactant gas mixture comprising at least 30 mole % of a co-reactant gas in an oxidizing environment under nucleation layer CVD conditions; ~~and~~

(b) deoxygenating the so formed nucleation layer ~~comprising ruthenium~~ in a reducing environment, in the absence of the ruthenium precursor/co-reactant gas mixture; and

~~wherein (a) and (b) are repeated sequentially and continuously~~ (c) sequentially repeating steps (a) and (b) until the ruthenium thin film of desired thickness is deposited onto the substrate.

66. (Original) The method of claim 65, wherein said deoxygenating comprises exposing said nucleation layer to a gas mixture comprising a reducing agent and optionally, an inert gas.

67. (Original) The method of claim 66, wherein the reducing agent comprises hydrogen.

68. (Currently Amended) The method of claim 65, wherein the deoxygenating step is conducted under conditions comprising pressure in a range of about 0.1 Torr to about 100 Torr and temperature in a range of about 250°C to about 350°C.

69. (Currently Amended) The method of claim 65, wherein the co-reactant gas is oxygen ~~deoxygenating step is conducted under conditions comprising temperature in a range of about 250°C to about 350°C.~~

70. (Currently Amended) The method of claim 65, wherein the temporal length of the deposition of the initial nucleation layer ~~in step (a)~~ is greater than that of the succeeding deposition steps ~~repetitions of step (a).~~

71. (Currently Amended) The method of claim 65, wherein the deposited nucleation layer comprises ruthenium oxide.

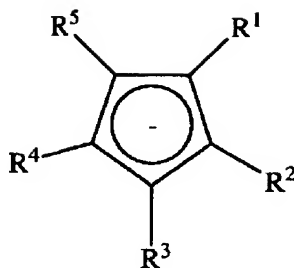
72. (Original) The method of claim 65, wherein the nucleation layer CVD conditions comprise temperature in a range of about 250°C and about 340°C.

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73. (Original) The method of claim 65, wherein the nucleation layer CVD conditions comprise pressure in a range of about 0.1 Torr and about 8 Torr.
74. (Currently Amended) The method of claim 65, wherein the ~~nucleation layer mixture comprises a first ruthenium precursor, a first co-reactant gas, and optionally a first ruthenium precursor/co-reactant gas mixture further comprises an inert gas.~~
75. (Currently Amended) The method of claim ~~[[74]]~~ 65, wherein the deoxygenation is accomplished by annealing first ruthenium precursor comprises a solid.
76. (Currently Amended) The method of claim ~~[[74]]~~ 65, wherein the first flow rate of the ruthenium precursor is sufficient to maintain surface reaction rate-limited deposition comprises a liquid.
77. (Currently Amended) The method of claim ~~[[74]]~~ 65, wherein the CVD conditions include a pressure of from about 0.1 Torr to about 5.0 Torr, a temperature of from about 250°C and about 340°C, and a flow rate of the first ruthenium precursor of from about 15 μmol/min to about 30 μmol/min and the co-reactant gas is oxygen and is present in a concentration of from about 80 mole % to about 95 mole % is dissolved in a solvent to form a first ruthenium precursor solution.
78. (Currently Amended) The method of claim 77, wherein the co-reactant gas is present in a concentration of from about 80 mole % to about 90 mole % solvent comprises a reducing solvent.
79. (Cancelled)
80. (Currently Amended) The method of claim ~~[[74]]~~ 65, wherein the ~~nucleation layer mixture comprises the first co-reactant gas comprises from at a concentration of about 80 mole% to about 95 mole% of the ruthenium precursor/co-reactant gas, based on the total number of moles of the nucleation layer mixture.~~
81. (Currently Amended) The method of claim ~~[[74]]~~ 80, wherein the first co-reactant gas comprises oxygen.
82. (Currently Amended) The method of claim ~~[[74]]~~ 65, wherein the first ruthenium precursor comprises a ruthenium compound selected from the group consisting of ruthenocenes, ruthenium β-diketonates, fluorinated ruthenium β-diketonates, ruthenium carbonyls, ruthenium oxides and ruthenium halides.
83. (Original) The method according to claim 82, wherein the ruthenocenes have the formula (Cp')Ru(Cp''), where Cp' and Cp'' can be same or different and have the general formula:



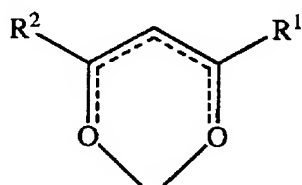
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where  $R^1 - R^5$  are independently selected from the group consisting of H, F, and straight-chained or branched  $C_1 - C_5$  alkyl groups.

84. (Original) The method according to claim 82, wherein the ruthenocene comprises  $Ru(EtCp)_2$  or  $Ru(Cp)_2$ .

85. (Original) The method according to claim 82, wherein the ruthenium  $\beta$ -diketonates have the formula  $Ru(\beta\text{-diketonate})_3$ , where  $\beta$ -diketonate has the general formula:



where  $R^1$  and  $R^2$  are independently selected from the group consisting of H, F, straight-chained or branched  $C_1 - C_5$  alkyl groups, and fluorine-substituted straight-chained or branched  $C_1 - C_5$  alkyl groups.

86. (Original) The method of claim 82, wherein the ruthenium  $\beta$ -diketonate comprises a compound selected from the group consisting of: tris(2,4-pentanedionate) ruthenium ( $Ru(acac)_3$ ); tris(1,1,1-trifluoro-2,4-pentanedionate) ruthenium ( $Ru(tfac)_3$ ); tris(2,2,6,6-tetramethyl-3,5-heptanedionate) ruthenium ( $Ru(thd)_3$ ); tris(1,1,1,5,5,5-hexafluoro-2,4-pentanedionate) ruthenium ( $Ru(hfac)_3$ ); tris(2,2,7-tetramethyl-3,5-octanedionato) ruthenium ( $Ru(tod)_3$ ); tris(6,6,7,7,8,8,8-heptafluoro-2,2-dimethyl-3,5-octanedionato) ruthenium ( $Ru(fod)_3$ ); and tris(2,4-octanedionato) ruthenium ( $Ru(od)_3$ ).

87. (Original) The method of claim 82, wherein the ruthenium  $\beta$ -diketonate comprises  $Ru(thd)_3$  or  $Ru(hfac)_3$ .

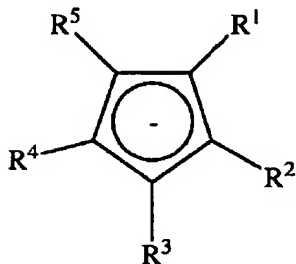
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88. (Currently Amended) The method of claim ~~[[74]]~~ 65, wherein the rate of introduction of the first ruthenium precursor is in a range of about 15  $\mu\text{mol/min}$  to about 30  $\mu\text{mol/min}$ .
89. (Currently Amended) The method of claim 65, wherein the substrate comprises a substrate material selected from the group consisting of silicon, silicon dioxide, silicon nitride, hafnium silicon oxide, hafnium silicon oxynitride ~~oxynitride~~, Co(WP), copper, titanium nitride, titanium aluminum nitride, tantalum nitride, tantalum pentaoxide, barium strontium titanate and lead zirconate titanate.
90. (Original) The method of claim 65, wherein the resistivity of the nucleation layer is less than about 250  $\mu\Omega\text{-cm}$ .
91. (Original) The method of claim 65, wherein the rate of deposition of the nucleation layer is in a range of about 5  $\text{\AA/min}$  to about 1  $\text{\AA/min}$ .
92. (Original) The method of claim 65, wherein the resistivity of the ruthenium thin film is in a range of about 15  $\mu\Omega\text{-cm}$  to about 50  $\mu\Omega\text{-cm}$ , and has a thickness in a range of from about 3.0 nm to about 10.0 nm.
93. (Original) The method of claim 65, wherein the resistivity of the ruthenium thin film is in a range of about 15  $\mu\Omega\text{-cm}$  to about 30  $\mu\Omega\text{-cm}$ , and has a thickness in a range of from about 4.0 nm to about 8.0 nm.
- 94-96. (Cancelled)
97. (New) A method for depositing a ruthenium thin film onto a substrate, said method comprising:
- (a) depositing a nucleation layer comprising ruthenium onto the substrate by chemical vapor deposition, wherein the nucleation layer is deposited using a nucleation layer mixture containing a first ruthenium precursor under nucleation layer CVD conditions; and
  - (b) depositing an upper layer comprising ruthenium onto the nucleation layer by chemical vapor deposition, wherein the upper layer is deposited using an upper layer mixture containing a second ruthenium precursor, different from the first, under upper layer CVD conditions.
98. (New) The method of claim 97, wherein the first and second ruthenium precursors are selected from the group consisting of ruthenocenes, ruthenium  $\beta$ -diketonates, fluorinated ruthenium  $\beta$ -diketonates, ruthenium carbonyls, ruthenium oxides and ruthenium halides.
99. (New) The method of claim 97, wherein the first ruthenium precursor is selected from the group consisting of ruthenium  $\beta$ -diketonates, fluorinated ruthenium  $\beta$ -diketonates, ruthenium carbonyls, and ruthenium oxides.

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100. (New) The method of claim 97, wherein the first ruthenium precursor is a ruthenium  $\beta$ -diketonate and the second ruthenium precursor is a ruthenocene.

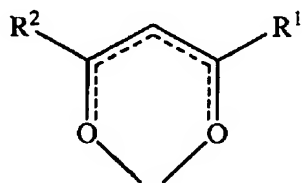
101. (New) The method of claim 100, wherein the ruthenocene has the formula  $(Cp')Ru(Cp'')$ , where  $Cp'$  and  $Cp''$  can be same or different and have the general formula:



where  $R^1 - R^5$  are independently selected from the group consisting of H, F, and straight-chained or branched  $C_1 - C_5$  alkyl groups.

102. (New) The method of claim 100, wherein the ruthenocene comprises  $Ru(EtCp)_2$  or  $Ru(Cp)_2$ .

103. (New) The method of claim 100, wherein the ruthenium  $\beta$ -diketonate has the formula  $Ru(\beta\text{-diketonate})_3$ , where  $\beta$ -diketonate has the general formula:



where  $R^1$  and  $R^2$  are independently selected from the group consisting of H, F, straight-chained or branched  $C_1 - C_5$  alkyl groups, and fluorine-substituted straight-chained or branched  $C_1 - C_5$  alkyl groups.

104. (New) The method of claim 100, wherein the ruthenium  $\beta$ -diketonate comprises a compound selected from the group consisting of: tris(2,4-pentanedionate) ruthenium ( $Ru(acac)_3$ ); tris(1,1,1-trifluoro-2,4-pentanedionate) ruthenium ( $Ru(tfac)_3$ ); tris(2,2,6,6-tetramethyl-3,5-heptanedionate) ruthenium ( $Ru(thd)_3$ ); tris(1,1,1,5,5,5-hexafluoro-2,4-pentanedionate) ruthenium ( $Ru(hfac)_3$ ); tris(2,2,7-tetramethyl-

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3,5-octanedionato) ruthenium ( $\text{Ru}(\text{tod})_3$ ); tris(6,6,7,7,8,8,8-heptafluoro-2,2-dimethyl-3,5-octanedionato) ruthenium ( $\text{Ru}(\text{fod})_3$ ); and tris(2,4-octanedionato) ruthenium ( $\text{Ru}(\text{od})_3$ ).

105. (New) The method of claim 100, wherein the ruthenium  $\beta$ -diketonate comprises  $\text{Ru}(\text{thd})_3$  or  $\text{Ru}(\text{hfac})_3$ .

106. (New) The method of claim 97 wherein the deposited nucleation layer comprises ruthenium metal.

107. (New) The method of claim 97, wherein the nucleation layer CVD conditions include a temperature of from about 250°C to about 340°C and a flow rate of the first ruthenium precursor of from about 15  $\mu\text{mol}/\text{min}$  to about 30  $\mu\text{mol}/\text{min}$  and the co-reactant gas is oxygen and is present in a concentration of from about 80 mole % to about 95 mole % and the upper layer CVD conditions include a temperature of from about 250°C to and about 400°C and a flow rate of the second ruthenium precursor of from about 5  $\mu\text{mol}/\text{min}$  to about 20  $\mu\text{mol}/\text{min}$  and from about 1 mole % to about 10 mole % of the second ruthenium precursor/co-reactant gas mixture comprises oxygen.

108. (New) The method of the claim 107, wherein second co-reactant gas comprises an oxygen:hydrogen gas mixture.

109. (New) The method of claim 108, wherein the more ratio of oxygen to hydrogen is from about 1:1 to about 1:3.

110. (New) The method of claim 97 wherein the flow of the first ruthenium precursor is sufficient to maintain a surface reaction rate-limited deposition and the flow of the second ruthenium precursor is less than that needed to maintain a surface reaction rate-limited deposition.

111. (New) The method of claim 110, wherein the nucleation layer CVD conditions include a temperature of from about 250°C to about 340°C and the first co-reactant gas comprises more than 30mole % of the first ruthenium precursor/co-reactant gas mixture.

112. (New) The method of claim 97, wherein the upper layer CVD conditions are more reducing than the nucleation layer CVD conditions.